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MULTIPLE APTITUDE NORMATIVE INTELLIGENCE TESTING THAT DISTINGUISHES U.S. AIR FORCE MQ-1 PREDATOR SENSOR OPERATORS FROM PEERS IN THE CIVILIAN GENERAL POPULATION AND AC-130 GUNSHIP SENSOR OPERATORS

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14. ABSTRACT

U.S. Air Force (USAF) MQ-1 Predator and MQ-9 Reaper sensor operators (SOs) have a critical role in intelligence, surveillance, reconnaissance (ISR); basic surface attack; and close air support (CAS) operations. The duties of the Predator/Reaper SOs are perceived by subject matter experts as having high levels of intelligence and visual-spatial aptitudes to successfully pass training and adapt to operational challenges. To date, there are no studies that assess the cognitive functioning of such a high-demand and critical enlisted career field, despite its important role in current USAF aviation. To fill the gap in the current literature, this study obtained intelligence testing on USAF Predator/Reaper SOs (n=51) and AC-130 gunship SOs (n=62) in an effort to (a) obtain normative intelligence data on incumbents to assess how such a specialized group of enlisted aircrew differs from the civilian, nonaircrew general population; (b) assess how the cognitive aptitudes (i.e., visual learning/memory, spatial analysis, visual attention to detail, and visual-constructive abilities) of incumbents specifically differ from SOs with ISR and CAS duties within a manned aircraft (i.e., AC-130); and (c) develop a distribution of intelligence tests scores for Predator/Reaper SO incumbents for use in aeromedical evaluations. The results of the study revealed that Predator/Reaper SOs have a significantly higher level of cognitive functioning in areas of visual construction and perceptual reasoning, visual attention to detail, spatial reasoning, visual learning and coding, as well as general conceptual reasoning. There were no significant differences in aptitude test scores between Predator/Reaper and AC-130 gunship SOs, indicating both groups share similar cognitive strengths.

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1.0 EXECUTIVE SUMMARY

U.S. Air Force (USAF) MQ-1 Predator and MQ-9 Reaper sensor operators (SOs) have a critical role in intelligence, surveillance, reconnaissance (ISR); basic surface attack; and close air support (CAS) operations. Predator/Reaper SOs are perceived by subject matter experts as having high levels of intelligence and visual-spatial aptitudes to successfully pass training and adapt to operational challenges. To date, there are no published studies assessing the cognitive functioning of such a high-demand and critical enlisted career field, despite the important role of Predator/Reaper SOs in current USAF aviation. To partially fill the gap in the current literature, this study obtained intelligence testing on USAF Predator/Reaper SOs (n=51) and AC-130 gunship SOs (n=62) in an effort to (a) obtain normative intelligence data on incumbents to assess how such a specialized group of enlisted aircrew differs from the civilian, nonaircrew general population; (b) assess how the cognitive aptitudes (i.e., visual learning/memory, spatial analysis, visual attention to detail, and visual construction abilities) of incumbents specifically differ from SOs with ISR and CAS duties within a manned aircraft (i.e., AC-130); and (c) develop a distribution of intelligence tests scores for Predator/Reaper SO incumbents for use in aeromedical evaluations. The results of the study revealed that Predator/Reaper SOs have a significantly higher level of cognitive functioning in areas of visual construction and perceptual reasoning, visual attention to detail, spatial reasoning, visual learning and coding, as well as general conceptual reasoning. There were no significant differences in aptitude test scores between Predator/Reaper and AC-130 gunship SOs, indicating both groups share similar cognitive strengths. A case vignette is provided to illustrate practical application of study findings to improve aeromedical evaluations of Predator/Reaper SO training applicants and incumbents. This study was conducted, in part, via research funds from the Defense Health Program.

2.0 INTRODUCTION

Remotely piloted MQ-1 Predator and MQ-9 Reaper sensor operators (SOs) have a central role in intelligence, surveillance, reconnaissance (ISR); basic surface attack (BSA); and close air support (CAS) operations. They fill a critical aircrew position for effective identification, targeting, and battle damage assessment of threats. Aside from motivation and a general interest in military operations, general intelligence and cognitive aptitude have a significant influence on the acquisition of job skills and performance of enlisted airmen in the U.S. Air Force (USAF). General cognitive ability and aptitudes (intelligence) have been demonstrated to predict attrition, acquisition of job skills, as well as quality of job performance in a broad body of research for both USAF and civilian occupations (e.g., Ref 1-4). However, there are no studies to date that assess the cognitive functioning of such a high-demand, critical aircrew position, despite the important role of Predator/Reaper SOs in current military aviation.

To partially fill the gap in the current literature, this study obtained intelligence testing on the USAF Predator/Reaper SOs in an effort to (a) obtain normative intelligence data on incumbents to assess how such a specialized group of enlisted aircrew differ from the civilian, nonaircrew general population; (b) assess how the cognitive aptitudes (i.e., visual learning/memory, spatial analysis, visual attention to detail, and visual construction abilities) of incumbents specifically differ from SOs with ISR, BSA, and CAS duties within a manned

aircraft (i.e., AC-130); and (c) develop a distribution of intelligence tests scores for Predator/Reaper SO incumbents for use in aeromedical evaluations.

2.1 High-Demand, High-Stress Career Field

Although Predator/Reaper aircraft shield the operator from challenges associated with physically flying in a combat zone, it would be incorrect to conclude that such operators do not face demanding occupational stressors (operational and combat related). It is perceived by many that such military flying in support of combat and/or humanitarian missions is an extraordinary high-demand, high-precision profession.

In general, Predator/Reaper SOs employ airborne sensors in manual or computer-assisted modes to actively and/or passively acquire, track, and monitor airborne, maritime, and ground objects; enemy combatants; and assets. As initially reported by Chappelle, McDonald, and King (Ref 5), SOs conduct operations and procedures in accordance with special instructions (SPINS), air tasking orders (ATOs), and rules of engagement (ROE). They assist remotely piloted aircraft (RPA) pilots through all phases of employment to include mission planning, flight operations, and debriefings. Specific duties include the following:

a. Conducting reconnaissance and surveillance of potential targets and areas of interest
b. Detecting, analyzing, and discriminating between valid and invalid targets using synthetic aperture radar; electrooptical, low-light, and infrared full-motion video imagery; and other active or passive tracking systems
c. Assisting in air navigation, air order of battle (AOB) integration, and fire control planning and determining effective weapons control and delivery tactics to achieve overall mission objectives
d. Receiving target briefs (9-liners) for weapons delivery and conducting immediate first phase battle damage assessments for up-channel coordination and potential reattack
e. Utilizing laser target marking systems to provide target identification and illumination for onboard weapons delivery and being responsible for terminal weapons guidance
f. Performing preflight and in-flight mission planning activities in accordance with unified combatant command and theater ROE
g. Understanding tactics, techniques, and procedures for friendly and enemy AOB assets
h. Operating mission planning ancillary equipment to initialize information for download to airborne mission systems
i. Receiving, interpreting, extracting, and disseminating relevant ATO, airspace control order, and SPINS information
j. Participating in postflight debriefing to establish mission accomplishments and potential procedural development
k. Researching and studying target imagery, friendly and enemy orders of battle, and offensive and defensive capabilities from various sources
l. Assembling target information, locating forces, and determining hostile intentions and possible tactics

As initially reported by Chappelle, McDonald, and King (Ref 5), it is important to note this enlisted aircrew position requires a person to visually discriminate and synthesize various images and complex data on several electronic screens while maintaining heightened vigilance to

numerous sources of visual and auditory information necessary for sustaining situational and spatial awareness. For example, the SO must effectively attend to the electronic video to calibrate instruments and distances of specific ground objects while maintaining vigilance to visual and auditory input from aircrew and command. The SO must also effectively communicate with aircrew to report the identification and discrimination of targets and to assist in the deployment of weapons. The SO must also sustain visual targeting during and following the employment of weapons to ensure accuracy and damage assessment. This includes visually observing the destruction of fixed and moving objects (such as buildings and cars), as well as the wounding and death of human combatants. The SO must be attentive to several procedural checklists and processes with advanced computer systems while simultaneously translating two-dimensional information from video screens into a four-dimensional mental imagery and spatial analyses.

As mentioned above, SOs must carry out their duties in a confined environment with specific rules of engagement, tactics, and techniques. It is a highly complex and challenging position. Please see Nagy, Muse, and Eaton (Nagy J, Muse K, Eaton G, *U.S. Air Force Unmanned Aircraft Systems Performance Analyses: Predator Sensor Operator Front End Analysis (FEA) Report*, SURVIAC-TR-10-043, 18 Aug 2006; available through the Defense Technical Information Center to U.S. Government agencies and their contractors only) for a more indepth view of the specific job tasks of SO duties as well as Pavlas et al. (Ref 6) and Reference 7 for a general taxonomy of knowledge, skills, and attitudes required of RPA operators in general. It stands to reason, based upon the description above, that a high level of general cognitive functioning and/or visual-spatial aptitudes are needed to successfully pass training and adapt to the operational requirements of this position.

2.2 Predator/Reaper SO Selection Standards

Though initial accessions are similar to those of other enlisted career fields, Predator/Reaper SO training applicants must meet several additional criteria for being considered for this special duty position. The enlisted personnel selected for Predator/Reaper SO duties are either direct accessions (new USAF recruits) who just graduated from basic military training or cross-trainees from other Air Force Specialty Codes. According to the Career Field Education and Training Plan, applicants must have a minimum Armed Services Vocational Aptitude Battery score of 64 (Mechanical) and 54 (Electrical) to enter the career field. This ensures that all training applicants meet general cognitive aptitude requirements that are higher than cut off scores for general airmen in the USAF. They must meet a wide range of physical and psychological medical standards as applied to ground-based controller guidelines according to Air Force instructions and aeromedical policy (Ref 8). The multiple standards that training applicants and incumbents are required to meet increase the relevance of having a high level of cognitive aptitude for performing high-demand, high-precision, aviation-related duties.

2.3 Brief Review of Sensor Operator Training Program

The following brief review of the SO training program is an excerpt adapted from Chappelle, McDonald, and King (Ref 5) and reproduced with the authors' permission.

Following basic military training, new enlisted recruits (as well as enlisted airmen cross-training from a nonaircrew career field) enter the Air Crew Fundamentals Course (AFC) at Lackland Air Force Base (AFB). This course is 12 to 14 trainings days and addresses topics such as aircrew publications and mission, flight medicine, basic aerodynamics of flying, and aircrew coordination (e.g., crew resource management and situational awareness).

Following AFC, all enlisted airmen (to include those cross-training from another aircrew career field) enter the Basic Sensor Operator Course (BSOC) at Randolph AFB. This course is approximately 18-21 training days and addresses initial skills training. BSOC utilizes technical training curricula derived from the Imagery Analysis Apprentice Course, AC-130 Gunship Sensor Operator Course, and Basic Airborne Operations Course. The course addresses issues in ISR, imagery and full-motion video analysis, geospatial information and mapping, imagery and video analyses of surface features and structures, electronics and missile systems, weapons systems and targeting, and training in aviation fundamentals.

The BSOC course is followed by the RPA Systems Fundamentals Course (UFC) at Randolph AFB. This course is approximately 20 training days and focuses on simulator training and the development of crew resource management skills. This course entails training alongside RPA pilot trainees to facilitate the development of crew interaction and communication skills. After the UFC course, the trainees are sent to MQ-1/MQ-9 Sensor Operator Initial Qualification (SOIQ) training. This lasts approximately 45 training days, during which they receive several training sorties, check rides, and additional academic instruction. Following the SOIQ course, they are sent to Combat Mission Readiness training for the next 3 mo. This training occurs at the operational units to which they are assigned. During this time, they are supervised and provided additional instruction and check rides. During this training, they are operating RPA Predators in "real world" operations in theater. They receive individual supervision and are rated on various factors of performance. Figure 1 is a chart of the RPA SO training pipeline.

It is important to note that the timely acquisition of such an important set of skills is critical. Training applicants are sent through a condensed training program within a short period of time. As a result, following successfully completion of training, many SOs will find themselves controlling highly sophisticated and complex imagery and targeting equipment and having a critical role in ISR and weapon-deployment combat operations within a year after enlisting in the USAF. This further elevates the importance of general cognitive functioning and aptitude for this position.

2.4 Intellectual Functioning and Cognitive Aptitudes of Predator/Reaper SOs

As can be surmised, Predator/Reaper operations can be viewed as a high-demand, high-precision activity. In addition to high levels of self-discipline and self-confidence, interviews with subject matter experts (SMEs) indicate a high level of intelligence, cognitive aptitude, and visual performance based abilities as central to successfully passing training and adapting to the operational demands of the duty position (Ref 5).

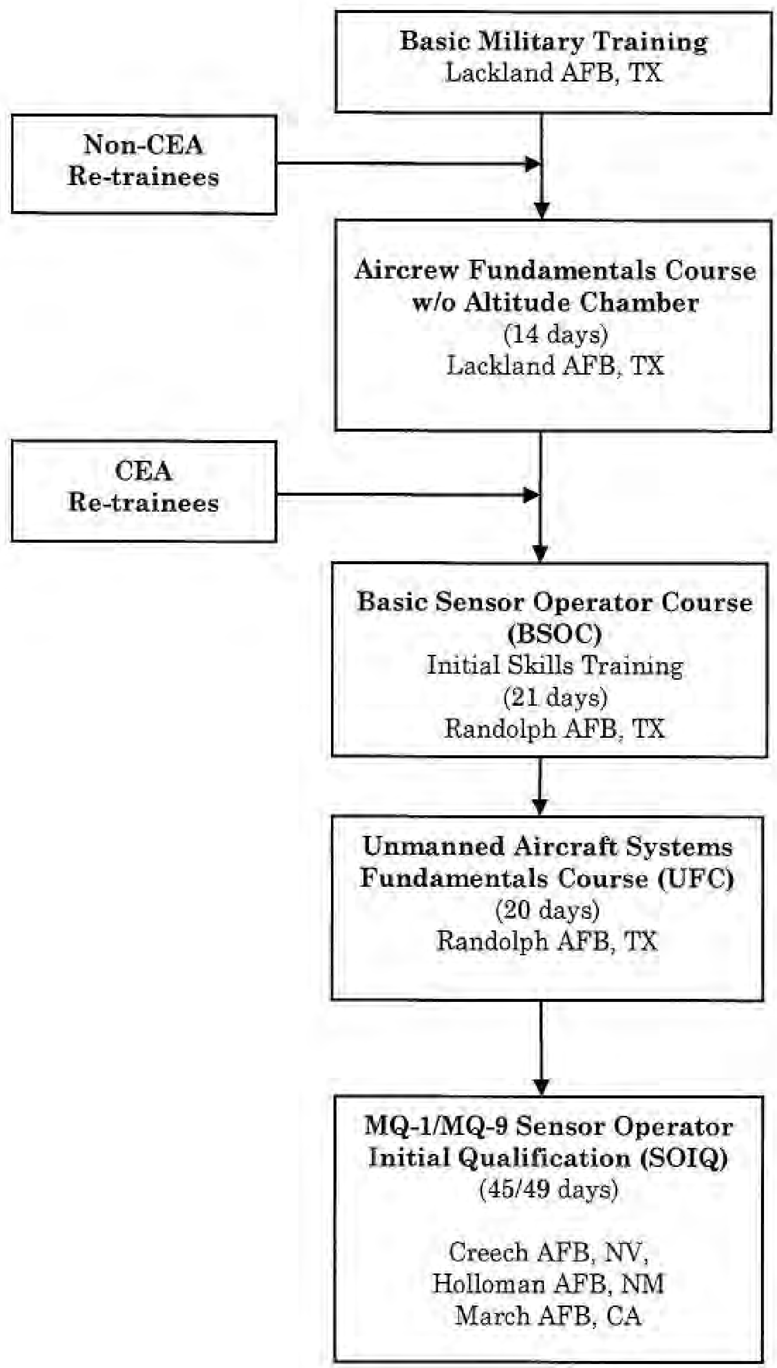

Figure 1. RPA Sensor Operator Training Pipeline
(CEA = career enlisted aviator)
(adapted from Ref 5)

Given the basic job description, selection standards, and training requirements and evidence gathered from SMEs, it is evident that general intelligence and visual-spatial skills may be critical determinants of a Predator/Reaper SO's abilities (Ref 5). Interviews with SMEs revealed that cognitive attributes perceived as critical to performance include the following (Ref 5):

- cognitive proficiency (speed and accuracy of information processing)
- visual perception (visual acuity for recognition, tracking, and analysis)
- attention (situational awareness and ability to attend to visual and auditory information)
- spatial processing (ability to manipulate images from two-dimensional to four-dimensional images)
- memory (visual and auditory, spatial)
- reasoning (ability to quickly and accurately problem solve and multitask and prioritize high-level information and procedures)

These cognitive attributes have been based on theory and SME perception, since there have been no follow-on studies to empirically validate the general cognitive ability and intelligence of such SOs.

It is important to consider some of the most carefully studied relationships between general intellectual ability and occupational outcomes that have been conducted in the military. Studies by Ree and Earles (Ref 1,2) as well as Ree, Earles, and Teachout (Ref 3) investigated the relative degree to which training success and job performance were predictable from specific aptitudes and general intellectual ability for a wide variety of occupational specialties in the USAF. This is particularly important given that training success in the USAF is often a prerequisite to a specialty assignment, and achievement in training has proven to be an excellent predictor of actual job performance. The results of their studies revealed that a significant portion of occupational training success is largely a function of general cognitive ability. As a result of the demanding nature of Predator/Reaper SO duties, it is reasonable to perceive a high level of cognitive functioning is required for this position.

2.5 Aeromedical Importance of Normative Test Data

While normative data regarding general intelligence and cognitive aptitudes exist for various occupations for use in assessment and selection of incumbents and training candidates, such norms are not established for USAF Predator/Reaper SOs. Information about the distribution of general intelligence and corresponding cognitive aptitude for such an important type of operator is critical for USAF medical and mental health providers who are tasked with evaluating the suitability of SO incumbents or training candidates who may (or may not) possess the cognitive aptitudes necessary to participate in such a challenging and high-risk occupation. According to USAF aeromedical policy (Ref 8), a training applicant with low general cognitive ability and borderline functioning in visual-spatial, visual learning, or visual construction abilities should not engage in Predator/Reaper SO duties. It is clear that deficits in such cognitive aptitudes may increase the risk of mission failure or mishaps at substantial costs to military operations and human life. USAF aeromedical policy requires intellectual assessments for a number of training candidates or incumbents with a history of various psychiatric illnesses or injuries (Ref 8). An aeromedical evaluation of a training applicant's or incumbent's

intellectual functioning is required when there is a history of cognitive difficulties (e.g., memory, attention, reasoning, information processing) stemming from a head injury, medical illness (e.g., bacterial meningitis), developmental disorder (e.g., attention deficit and hyperactivity, learning disorder), or emotional problem (e.g., depression, anxiety).

It is difficult to effectively evaluate a training applicant's or incumbent's scores on intelligence testing without normative data specific to RPA SOs. It is unclear if normative data based upon the civilian, nonaircrew general population are inadequate for evaluating Predator/Reaper SOs. In particular, the use of general population norms to determine whether or not a training applicant's score is within normal limits for such a high-demand, high-risk career field may he inadequate and actually mask aeromedically significant cognitive difficulties. Taken together, the above issues highlight the need for the clinical and aeromedical importance of establishing normative data on the general intellectual and cognitive functioning of today's USAF Predator/Reaper SO training applicants and incumbents.

Although the general cognitive ability of Predator/Reaper SO training applicants (or incumbents) is easily estimated from his or her responses to the Air Force Qualifying Test (AFQT), there is no clear data regarding the distribution of intelligence testing for those enlisted airmen who successfully pass training. Furthermore, as mentioned previously by Chappelle et al. (Ref 9), the AFQT does not directly assess the visual-spatial aptitudes deemed critical to performance reported by SMEs in the study by Chappelle, McDonald, and King (Ref 5).

2.6 Predator/Reaper SO vs. AC-130 Gunship SO Cognitive Aptitudes

Based upon the authors' discussions with Air Combatant Command (ACC) and Air Force Special Operations Command (AFSOC) training and SO career field leadership, there is debate between the cognitive aptitudes required for performing ISR, BSA, and CAS SO duties in manned and unmanned airframes. Although there is a significant overlap in imagery analyses, targeting, and identification of enemy assets and combatants, it is unknown if AC-130 gunship SOs have a higher level of functioning due to the performance of their duties under the stressors of flying in combat. It is perceived that because they must sustain focus under exceptionally stressful circumstances, they likely have a higher level of intellectual functioning. However, others have argued that Predator/Reaper SOs likely have a higher level of intellectual functioning due to the requirement of performing critical ISR and weapon-deploying duties on a daily basis while having to juggle the demands of their personal domestic life. Regardless, there is no empirical data to substantiate or support either assumption. If it is discovered that intellectual functioning and cognitive aptitude between both groups are compatible, then it increases the possibility of cross-training between the two SO career fields, subsequently enabling career enrichment and broadening.

2.7 Purpose of the Study

As mentioned previously, to fill the gap in the current literature, this study obtained intelligence testing on USAF Predator/Reaper SOs in an effort to (a) obtain normative intelligence data on incumbents to assess how such a specialized group of enlisted aircrew differ from the civilian, nonaircrew general population; (b) assess how the cognitive aptitudes (i.e., visual learning/memory, spatial analysis, visual attention to detail, and visual construction abilities) of incumbents specifically differ from SOs with ISR and CAS duties within a manned

aircraft (i.e., AC-130); and (c) develop a distribution of intelligence tests scores for Predator/Reaper SO incumbents for use in aeromedical evaluations.

3.0 METHODS

3.1 Participants

3.1.1 RPA Sensor Operators. A total of 51 active duty MQ-1 Predator/Reaper SOs who passed training volunteered to participate in cognitive testing for this study. There were 45 (88.24%) male and 6 (11.76%) female participants, with an average age of 29.22 yr (standard deviation (SD) = 7.18). There were 18 (35%) between the rank of Airman and Senior Airman (E1-E4), 17 (33%) between the rank of Staff Sergeant and Technical Sergeant (E5-E6), and 7 (14%) between the rank of Master Sergeant and Chief Master Sergeant (E7-E9); 9 (18%) did not report their rank.

3.1.2 AC-130 Gunship Sensor Operators. A total of 62 (approximately 48% of the total USAF AC-130 gunship SO population) active duty AC-130 gunship SOs who passed training volunteered to participate in cognitive testing for this study. There were 58 males and 4 females, with an average age of 31.57 yr (SD = 7.18). There were 12 (19%) between the rank of Airman and Senior Airman (E1-E4), 30 (48%) between the rank of Staff Sergeant and Technical Sergeant (E5-E6), and 17 (27%) between the rank of Master Sergeant and Chief Master Sergeant (E7-E9); 3 (5%) did not report their rank.

The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and AFI 40-402. The purpose and methodology of the study were reviewed and approved by the Wright-Patterson AFB Institutional Review Board and assigned protocol numbers F-WR-2009-0027-E and F-WR-2009-0047-E.

3.2 Measures

The Multidimensional Aptitude Battery-Second Edition (MAB-II) (Ref 10) is a broad-based test of intellectual ability. It is fashioned after the Wechsler Adult Intelligence Scale (Ref 11), which is the most widely used, individually administered test of intelligence among neuropsychologists. The MAB-II was chosen because it is easily administered as a paper-pencil based test in a group setting. The MAB-II has 10 subtests that are each 7 min long, and all items have five multiple-choice responses. The paper-pencil based MAB-II requires 100 min to complete and can be administered in group settings. The test is separated into verbal abilities subtests (i.e., information, comprehension, arithmetic, similarities, and vocabulary) and visual performance abilities subtests (digit symbol coding, picture completion, spatial analyses, picture arrangement, and object assembly). This test also produces overall verbal (VIQ), performance (PIQ), and full-scale (FSIQ) intelligence quotient scores. MAB-II normative subtest scores for the general population have a mean score of 50 and an SD of 10. Index scores (i.e., VIQ, PIQ, and FSIQ) for the general population have a mean of 100 and an SD of 15. The MAB-II manual has well-documented internal consistency, validity, and test-retest reliability coefficients. See Table 1 for a description of the general intellectual abilities each subtest measures.

Table 1. Brief Description of Cognitive Aptitudes Measured by the MAB-II

Subtest	Aptitude Measured
Verbal Subtests	
Information (INF)	General fund of knowledge on diverse topics; long-term memory
Comprehension (COM)	Social reasoning, judgment, and comprehension
Arithmetic (ARI)	General and numerical reasoning and problem solving
Similarities (SIM)	General conceptual and abstract reasoning and problem solving; flexibility and adjustment to novelty
Vocabulary (VOC)	Verbal reasoning, classification, and openness to new verbal information; ability to retrieve verbal concepts
Performance Subtests	
Digit Symbol (DS)	Adaptation to new set of demands; visual learning and coding, figural memory, and speed of information processing
Picture Completion (PC)	Visual attention to detail; knowledge of common objects; perceptual and analytical skills
Spatial Analysis (SP)	Ability to visualize and mentally rotate abstract two-dimensional images of objects in different positions; figural-domain reasoning
Picture Arrangement (PA)	Visual reasoning; ability to identify a meaningful sequence; perceptual reasoning
Object Assembly (OA)	Visualization and visual construction skills; perceptual analytical skills needed to identify a meaningful object from left-to-right sequence

3.3 Procedure

USAF operational leaders within ACC and AFSOC line leadership were contacted regarding the purpose of the study and the need for objective cognitive aptitude testing from personnel within the RPA MQ-1 Predator/MQ-9 Reaper and AC-130 gunship SO career fields to improve the aeromedical evaluation process of such airmen. Military leadership encouraged all available SOs to participate in the testing. A list of volunteers for testing was solicited by leadership through e-mail, phone, and in-person requests. Participants were informed of the purpose of the study and that nonparticipation would not have a negative effect on their occupational prospects. They were informed that individual test results were confidential and would not be included in their military medical or personnel records. They were also instructed that leadership within their chain-of-command would not have access to individual scores and their test results would remain locked within the Neuropsychiatry Branch at the USAF School of Aerospace Medicine (USAFSAM). They were instructed on the purpose of the research, which was to develop occupationally specific normative data for intelligence testing and to improve the aeromedical evaluation process for sensor operators supporting remotely piloted and manned aircraft operations. They were instructed on how they could obtain access to their test scores, if desired, at a later date. Volunteers were assigned to small groups of 5 to 10 participants and

tested in a classroom within the squadron facility. Participants were given the paper and pencil version of the MAB-II. Standardized instructions were read aloud from the MAB-II manual. It is important to note that the MAB-II intelligence testing data from AC-130 gunship SOs obtained for this study were also used in a previous USAFSAM technical report by Chappelle et al. (Ref 9).

4.0 RESULTS

Table 2 provides the percentile equivalent scores according to the distribution of T-scores (based on the civilian population normative data) for the subtests and index scores for the MAB-II. Analyses of the data indicate a normal distribution for each of the variables. The table shows the distribution of T-scores according to specific percentiles. For example, in the first row, although a T-score of 47.00 for the *Information* subtest is in the 39th percentile and within normal limits for the civilian population according to the MAB-II manual, Table 2 indicates that such a score corresponds with the 10th percentile and is well-below normal limits based upon the distribution of T-scores for the sample of Predator/Reaper SOs.

Table 3 shows the means and standard deviations for the domain and facet scores for Predator/Reaper and AC-130 gunship SOs and the civilian combined male/female adult normative sample for the MAB-II. Two tailed t-tests were conducted comparing the means for Predator/Reaper to gunship SOs and for the civilian normative sample for subtests and indices. For purposes of this study, we considered differences that met the following criteria to be operationally significant: (a) the a priori Type I error rate was set at $p < .05$ and (b) the effect size was equal to or greater than $d = .50$ (Ref 12).

Table 2. Distribution Table of Predator/Reaper SO T-Scores for the MAB-II

MAB-II Subtests	Percentile						
	5th	10th	25th	50th	75th	90th	95th
Verbal Subtests							
Information	45	47	53	60	65	68	71
Comprehension	46	49	53	55	59	61	62
Arithmetic	43	46	52	55	60	64	65
Similarities	49	51	53	56	58	63	64
Vocabulary	45	46	50	54	57	62	64
Performance Subtests							
Digit Symbol	45	47	51	55	61	67	69
Picture Completion	46	48	53	59	63	69	69
Spatial Analyses/Reasoning	42	46	53	59	63	68	71
Picture Arrangement	44	44	51	55	61	64	68
Object Assembly	47	49	56	61	66	69	70
Indices							
Verbal Intelligence	96	97	100	106	113	116	118
Performance Intelligence	92	94	102	108	119	125	129
Full-Scale Intelligence	96	98	103	107	114	119	121

Note: The distribution table of T-scores enables comparison of how Predator/Reaper SO T-scores for each subtest and index on the MAB-II differ when compared with the standard distribution of general population, civilian, nonaircrew T-scores. The distribution of T-scores also corrects for differences dues to age.

Table 3. Means, Standard Deviations, and Results for Between Groups Statistical Comparisons

Domain/Facet	Predator/Reaper SOs			Gunship SOs			Civilian Sample		RPA SOs vs. Civilian Sample			RPA SOs vs. Gunship SOs		
	N	Mean	SD	N	Mean	SD	Mean	SD	t-test	p-value	Cohen's d Effect Size	t-test	p-value	Cohen's d Effect Size
Verbal Intelligence														
Information	51	60.1	8.3	62	58.1	8.1	50.0	10.0	8.10	0.00	***1.10***	1.00	0.32	N/A
Comprehension	51	56.0	4.6	62	54.2	5.6	50.0	10.0	7.65	0.00	***0.77***	1.60	0.11	N/A
Arithmetic	51	53.9	7.8	62	55.2	7.0	50.0	10.0	3.29	0.00	0.43	-1.20	0.23	N/A
Similarities	51	56.5	4.9	62	55.7	4.8	50.0	10.0	7.91	0.00	***0.82***	0.39	0.70	N/A
Vocabulary	51	55.0	6.1	62	52.8	5.8	50.0	10.0	5.18	0.00	***0.61***	2.00	0.05	***0.38***
Performance Subtests														
Digit Symbol	51	57.1	7.6	62	55.4	8.1	50.0	10.0	6.15	0.00	***0.80***	0.75	0.45	N/A
Picture Completion	51	58.3	7.6	62	59.0	8.2	50.0	10.0	7.57	0.00	***0.93***	-0.49	0.63	N/A
Spatial Analysis	51	58.5	7.3	62	55.5	10.2	50.0	10.0	7.59	0.00	***0.97***	1.51	0.13	N/A
Picture Arrangement	51	54.1	7.7	62	56.2	7.8	50.0	10.0	3.51	0.00	0.46	-2.10	0.04	***-0.39***
Object Assembly	51	60.0	7.3	62	60.2	6.7	50.0	10.0	9.00	0.00	***1.15***	-0.63	0.53	N/A
Verbal Intelligence (VIQ)	51	107.6	8.4	62	105.6	7.5	100.0	15.0	5.87	0.00	***0.66***	1.57	0.12	N/A
Performance Intelligence (PIQ)	51	109.1	12.0	62	109.7	11.7	100.0	15.0	5.03	0.00	***0.67***	-0.27	0.78	N/A
Full Scale Intelligence (FSIQ)	51	108.8	7.9	62	108.0	7.8	100.0	15.0	6.79	0.00	***0.73***	0.51	0.61	N/A

Figure 2 contains box plots that depict the range and average scores for RPA and AC-130 gunship sensor operators for MAB-II indices. Raw scores were converted to standard scores for this figure. Standard scores in the general population have a mean of 100 and a standard deviation of 15. The diamond shape is the mean. The horizontal line within each box is the median. The areas within each box represent one standard deviation above and below the mean. The arms at the upper and lower ends indicate the range. VIQ = verbal intelligence quotient, PIQ = performance intelligence quotient, and FSIQ = full-scale intelligence quotient.

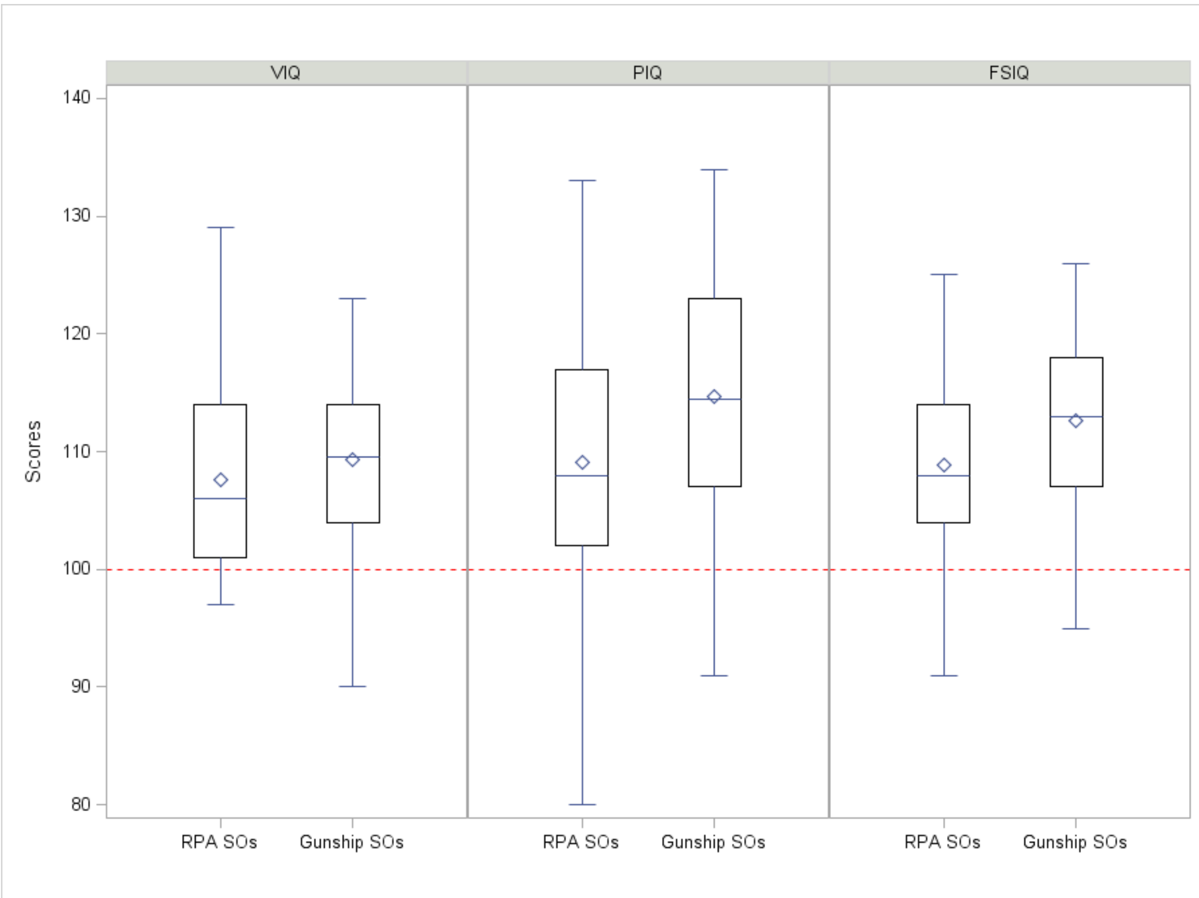

Figure 2. Range and Average Scores for RPA and AC-130 Gunship Sensor Operators for MAB-II Indices

Figure 3 contains box plots that depict the range and average scores for RPA and AC-130 gunship sensor operators for the verbal subtests from the MAB-II. Raw scores were converted to standard scores for this figure. Standard scores in the general population have a mean of 100 and a standard deviation of 15. The diamond shape is the mean. The horizontal line within each box is the median. The areas within each box represent one standard deviation above and below the mean. The arms at the upper and lower ends indicate the range. INF = information, COMP = comprehension, ARIT = arithmetic, SIM = similarities, and VOC = vocabulary.

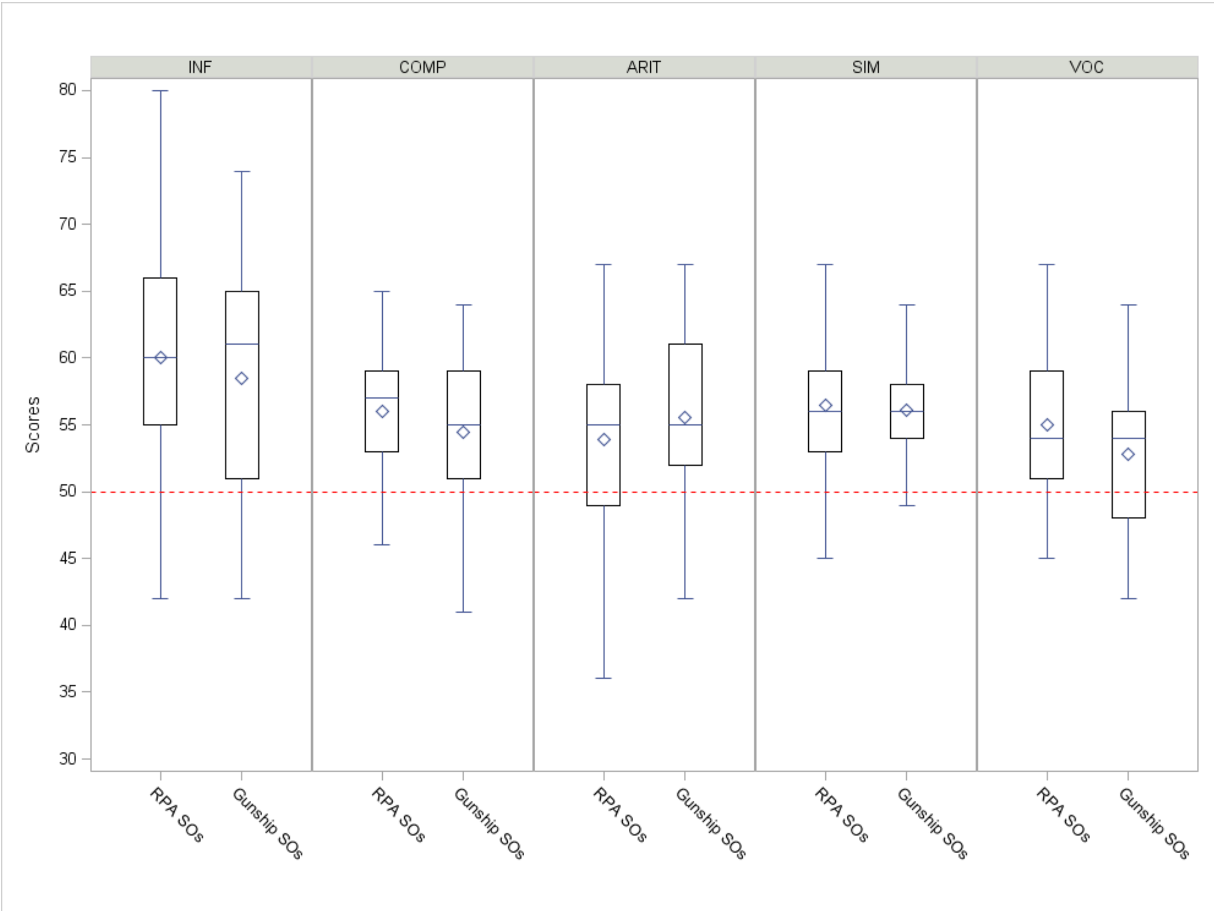

Figure 3. Range and Average Scores for RPA and AC-130 Gunship Sensor Operators for Verbal Subtests from the MAB-II

Figure 4 contains box plots that depict the range and average scores for RPA and AC-130 gunship sensor operators for the performance subtests from the MAB-II. Raw scores were converted to standard scores for this figure. Standard scores in the general population have a mean of 100 and a standard deviation of 15. The diamond shape is the mean. The horizontal line within each box is the median. The areas within each box represent one standard deviation above and below the mean. The arms at the upper and lower ends indicate the range. DSY = digit symbol, PICC = picture completion, SPAT = spatial analyses, PICA = picture arrangement, and OA = object assembly.

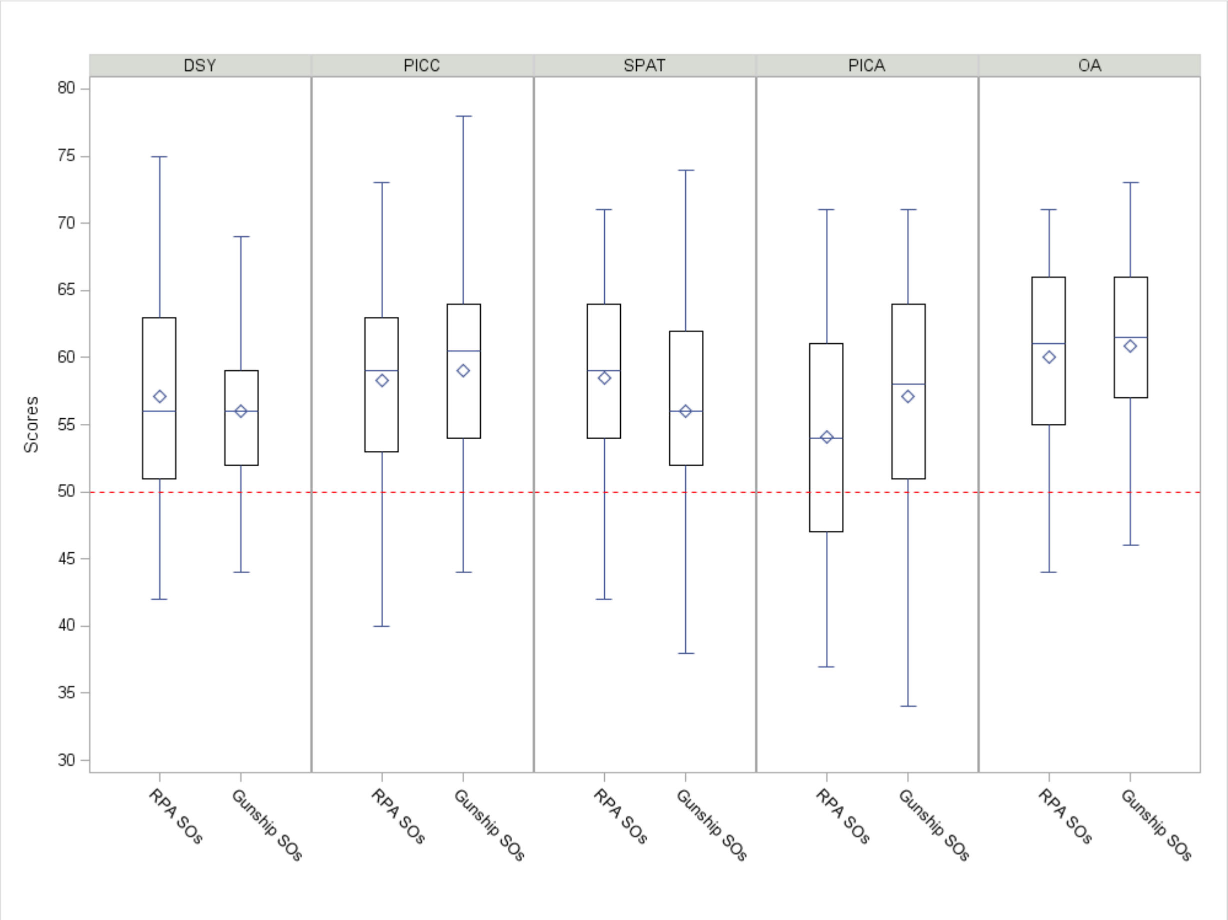

Figure 4. Range and Average Scores for RPA and AC-130 Gunship Sensor Operators for Performance Subtests from the MAB-II

5.0 DISCUSSION

5.1 Predator/Reaper SOs vs. General Population

The first objective of this study was to obtain normative intelligence testing on Predator/Reaper SOs to assess how the cognitive aptitudes of such a specialized group of enlisted airmen differ from the civilian general population.

The results of the study reveal that the general intellectual functioning of Predator/Reaper SOs who successfully pass training is close to the high average range (MAB-II standard scores for VIQ = 107.6, 68th percentile; PIQ = 109.1, 73rd percentile; and FSIQ = 108.8, 70th percentile) and higher than the general population. More specifically, large differences were found between the mean scores for the general population and Predator/Reaper SOs on subtests that assessed general fund of knowledge on diverse topics (i.e., mean T-score for information = 60.1, 84th percentile), visual construction skills and perceptual-analytical reasoning (i.e., mean T-score for object assembly = 60, 84th percentile.), spatial figure-domain reasoning and mental rotation (i.e., mean T-score for spatial analyses = 58.5, 81st percentile), visual attention to detail (i.e., mean T-

score for picture completion = 58.3, 81st percentile), visual learning and coding (i.e., mean T-score for digit symbol = 57.1, 75th percentile), general conceptual and abstract reasoning (i.e. mean T-score for similarities = 56.5, 73rd percentile), as well as general social reasoning and judgment (i.e., mean T-score for comprehension = 56; 73rd percentile). Given that their scores were on cognitive aptitude subtests with limited response time, their performance is also indicative of a high level of cognitive proficiency (i.e., high level of speed and accuracy of information processing). Overall, Predator/Reaper SO performances on these subtests are significantly higher than the general population and within the high average of functioning. It is also evident from the distribution of scores in Table 1 that the cognitive performance within the group of RPA SOs does not vary nearly as much as those in the general population, reflecting a much more cognitively homogenous group.

The results of these findings support the report of SMEs in an earlier qualitative study by Chappelle, McDonald, and King (Ref 5) that the general cognitive function of Predator/Reaper SOs is higher than the general population and that SOs have strengths in cognitive proficiency, spatial processing, reasoning, and visual perception. Such visual performance based abilities are considered "critical" by SMEs for SOs to pass training and manage the high demand of their operational duties during flight. These findings are particularly important to the aeromedical evaluation of Predator/Reaper SO training applicants and incumbents who have been medically disqualified due to a history of an illness affecting their psychological disposition and who are seeking an aeromedical waiver to return to fly as soon as possible.

5.2 Predator/Reaper SO vs. Gunship SOs

The second objective of this study was to assess how key cognitive aptitudes for Predator/Reaper SOs differ from SOs with similar duties that support manned aircraft (i.e., AC-130 gunship).

It is important to note that the results of this study do not find any operationally meaningful significant difference in cognitive aptitude scores between Predator/Reaper and AC-130 gunship SOs. Based upon anecdotal evidence from the authors' discussions with training managers for both career fields, there was concern that there would be a discrepancy in the aptitudes between the different groups. However, the results of this study do not support such assumptions. Rather, the two groups are relatively similar and share much of the same strengths in regards to visual performance based aptitudes (i.e., visual reasoning and attention to detail, visual construction abilities, and visual-spatial analyses) as well as general fund of knowledge and information when compared with age-related peers in the civilian general population. Although gunship SOs scored slightly higher on a test of visual reasoning and Predator SOs scored slightly higher on a measure of verbal reasoning, the magnitude of the difference was small (i.e., Cohen's *d* effect size = .38 and -.39, respectively) and did not meet the required cut value (i.e., Cohen's *d* effect size of .50) to be considered operationally relevant. The results of this study suggest that the current selection processes for identifying enlisted airmen for participation in weapon-deploying SO duties for either remotely piloted or manned aircraft are selecting airmen with equivalent cognitive aptitudes and strengths. However, caution is urged to not generalize the results of this study to nonweapon-deploying SOs (e.g., SOs from manned aircraft such as J-STARS or AWACS) or similar image analysts supporting intelligence operations.

5.3 Aeromedical Application and Clinical Vignette

The third objective of this study was to develop occupationally specific normative data and distribution of intelligence aptitude scores for use in clinical psychological aeromedical evaluations.

As described earlier by Chappelle et al. (Ref 9), occupationally specific normative data are essential to evaluating intelligence testing scores for enlisted airmen in special aircrew positions. Through the use of occupationally specific data, it is possible to view the strengths and direction of an individual's cognitive aptitudes as compared with others within a specific career field. For example, if a Predator/Reaper SO training candidate's performance on an intelligence test demonstrates that he or she (when compared with Predator/Reaper SO incumbents) is someone who has notable weaknesses in spatial-analyses, visual reasoning, visual memory and learning, as well as visual construction aptitudes, then there would be reason to be concerned with his or her cognitive ability to acquire SO skills in a timely fashion and effectively adapt to the demanding nature of SO duties. Another example, illustrated by Chappelle et al. (Ref 9), is when an incumbent has been disqualified from flying due to a history of illness (e.g., bacterial meningitis). If the incumbent's test scores reflect the absence of cognitive difficulties and the presence of a high level of general intellectual, as well as visual performance based functioning (and is within normal limits when compared with occupationally specific normative data), then there may be reason to conclude the person could return to his or her aircrew duties.

Although general population norms can be helpful in distinguishing how a Predator/Reaper SO applicant's or incumbent's intellectual functioning compares with an age-matched cohort, it does not allow for determining how a person compares with others within the career field. Therefore, it is important to utilize Tables 1 and 2 in this study. The percentile table, in particular, allows a psychologist to determine how a specific score compares with the distribution of scores for Predator/Reaper SO incumbents as a group. In general, scores that fall above the 90th or below the 10th percentile can be viewed as outliers and significantly different from most others.

The utility of these data is illustrated by the case of a 25-yr-old male Predator/Reaper SO with a history of bacterial meningitis. His history of such an illness disqualifies him from SO duties according to USAF aeromedical policy (Ref 8, sect. 6I). In this case, following the required period of observation prior to returning to fly, he needed an evaluation to determine if his history of bacterial meningitis was fully resolved and if he met the aeromedical waiver criteria for returning to his operational duties as an RPA SO. He was referred to the installation's active duty psychologist for an evaluation. The psychologist who evaluated the SO included intelligence testing (i.e., MAB-II) as part of his evaluation.

Based upon his responses to items on the MAB-II, the psychologist reported his scores (when compared with males in the civilian, nonaircrew normative sample) to be within normal limits and compatible with others in the civilian, nonaircrew general population. For example, when compared with others in the general population, the scores of his FSIQ (98 = 45th percentile), PIQ (94 = 34th percentile), and visual performance based subtests of object assembly (47 = 39th percentile), spatial analyses (46, 37th percentile), picture completion (46 = 37th percentile), and digit symbol (45 = 30th percentile) were within normal limits. However, utilizing the distribution of test scores from Table 1 to compare his performance to occupationally specific normative data for Predator/Reaper SOs, such scores were at or below the 10th percentile. His scores revealed his cognitive functioning was outside normal limits and

within borderline to impaired range of functioning when compared with Predator/Reaper SO data. Furthermore, his scores showed relative weaknesses in those visual performance based aptitudes considered critical to SO duties, as reported by Chappelle, McDonald, and King (Ref 5).

After reviewing additional information and an exhaustive evaluation that involved collateral baseline data regarding his intellectual functioning, the psychologist concluded that the SO's current cognitive aptitude had not returned to baseline, was substantially lower than SO incumbents, and thereby not compatible with the challenging and dangerous conditions associated with operations of the MQ-1 Predator and MQ-9 Reaper. As a result, his cognitive disposition did not appear to meet the aeromedical waiver criteria for ground-based controller standards, and he could benefit from additional time to heal prior to resumption of his duties. The occupationally specific normative data included in this study may help a USAF psychologist accurately interpret test scores in context of occupationally specific normative data and render difficult, yet critical, decisions regarding readiness to return to aviation-related duties where the safety risks and potential losses from a mishap are exceptionally high.

5.4 Limitations to the Study

Although this study used a reasonable sample size of Predator/Reaper SOs (n = 51) utilizing a reliable and valid intelligence test, there are limitations. First, it is unclear how prone the study is to sampling bias and error, i.e., how well the results of this study are dependent upon how well the sample represents the population of Predator/Reaper SOs. The degree of sampling error may be revealed via a repeat study with a different sample. Second, based upon the authors' discussions with line commanders, there is the perception that Reaper SO duties may require a higher level of cognitive aptitude due to the increased complexity of weapon-deployment missions. As a result, it is unknown if Reaper SOs as a group differ from Predator SOs and other weapon-deploying SOs within manned aircraft (such as the AC-130 gunship). It is recommended that an additional study be conducted separating and comparing Predator with Reaper SOs. Third, generalizing the results of this study to other SOs in other airframes (i.e., JSTARS and AWACS) is likely not appropriate. The selection processes, type of aviation-related duties, and demands differ significantly. Another variable that may have impacted study results is the voluntary nature of participants. It is possible that only those who knew they would perform well volunteered to participate in cognitive testing, thus skewing the group results of incumbents. Lastly, as reported by Chappelle et al. (Ref 9), aeromedical evaluations that involve the assessment of Predator/Reaper SO training candidates (or incumbents) being considered for SO duties or returning to fly should include collateral sources of information from others. Other sources of information (e.g., conversations with spouse, military commanders, supervisors), and clinical interviews are needed to fully understand the reliability and validity of specific cognitive test scores as they relate to Predator/Reaper SO training and performance.

6.0 CONCLUSIONS

The results of this study suggest that there are significant group differences between Predator/Reaper SO normative scores and those utilized in the MAB-II civilian, nonaircrew general population normative sample. As a result, USAF flight medicine physicians and psychologists should be sensitive to such differences and utilize the occupationally specific

normative data that accurately represent the group with which the Predator/Reaper SO is being compared and the purpose of an evaluation. Otherwise, as in the case illustrated above, a person may mistakenly conclude that an SO incumbent's (or training candidate's) scores are within normal limits when, in fact, the scores are not when compared with occupationally specific normative data for Predator/Reaper SOs. Appropriate normative data are critical to the accurate and effective interpretation of intelligence test scores that are often a part of the aeromedical evaluation process for identifying a person's readiness for participating in high-risk, high-demand, high-precision aviation-related duties. The results of this study also reveal no operationally significant differences between Predator/Reaper SO intelligence test scores and SOs with weapon-deploying duties who support manned aircraft. This suggests that the cognitive aptitudes are similar between both groups. However, this does not indicate that enlisted airmen SOs can cross-train into manned and remotely piloted career fields with consistent levels of performance. The acquisition of skills and adaptation to the operational demands of RPA or manned aircraft SO duties are also highly dependent upon additional factors such as personality traits and motivation (Chappelle WL, Patterson J, Sowin T, Randall B, *Critical Psychological Attributes of U.S. Air Force AC-130 Gunship Sensor Operators According to Subject Matter Experts*, AFRL-SA-BR-TR-2009-1015, Feb 2009; available through the Defense Technical Information Center to Department of Defense (DoD) and U.S. DoD contractors only) (Ref 5). That being said, though, the fact that these two career fields possess similar intelligence test scores suggests that cross-training or merging of these weapon-employment positions may be feasible, especially given current budgetary and force composition pressures. Further investigation into the personality traits and motivations of RPA SOs is, therefore, warranted.

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LIST OF ACRONYMS

ACC	Air Combat Command
AFB	Air Force Base
AFQT	Air Force Qualifying Test
AFSOC	Air Force Special Operations Command
AOB	air order of battle
ATO	air tasking order
BSA	basic surface attack
BSOC	Basic Sensor Operator Course
CAS	close air support
DoD	Department of Defense
FSIQ	full-scale intelligence quotient
ISR	intelligence, surveillance, reconnaissance
MAB-II	Multidimensional Aptitude Battery-Second Edition
PIQ	performance intelligence quotient
ROE	rules of engagement
RPA	remotely piloted aircraft
SD	standard deviation
SME	subject matter expert
SO	sensor operator
SOIQ	Sensor Operator Initial Qualification
SPINS	special instructions
USAF	U.S. Air Force
USAFSAM	U.S. Air Force School of Aerospace Medicine
VIQ	verbal intelligence quotient